NASA VIEW OF SPACE AND RANGE STANDARDIZATION

NASA/DoD/RCC Telemetry Networks

Session #18
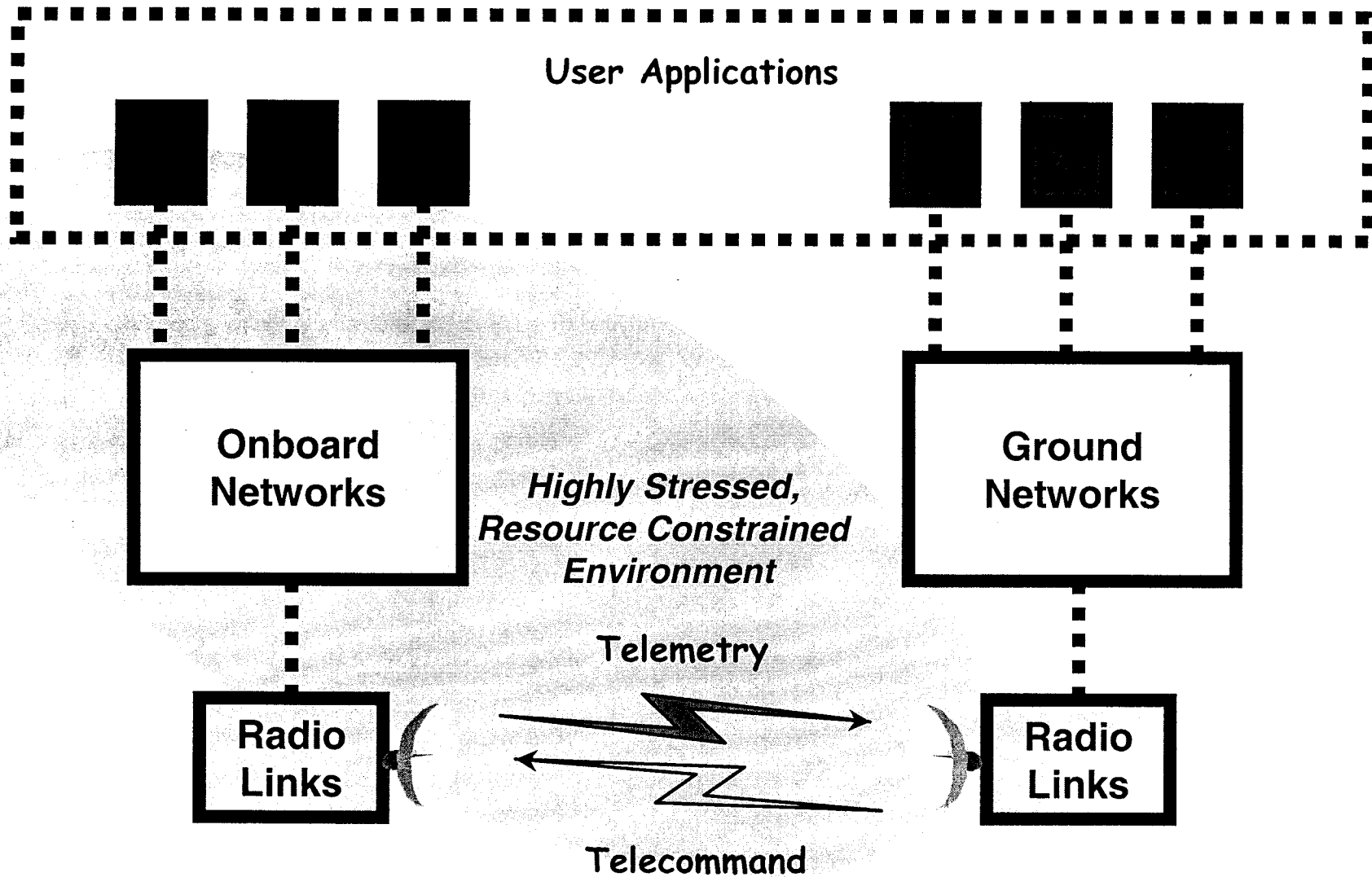*International Telemetering Conference*

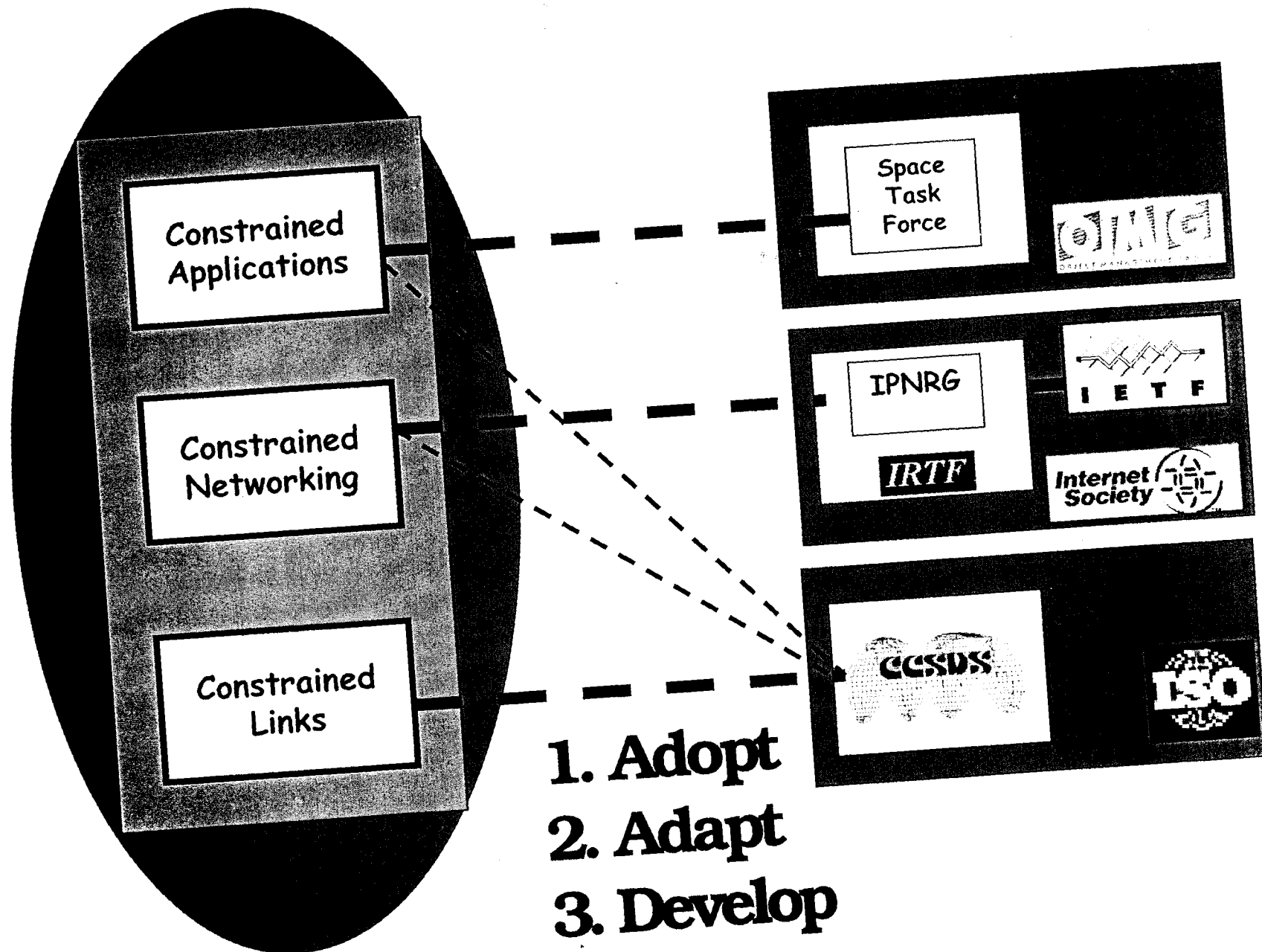*San Diego, California, USA*
25 October 2000

Adrian J. Hooke
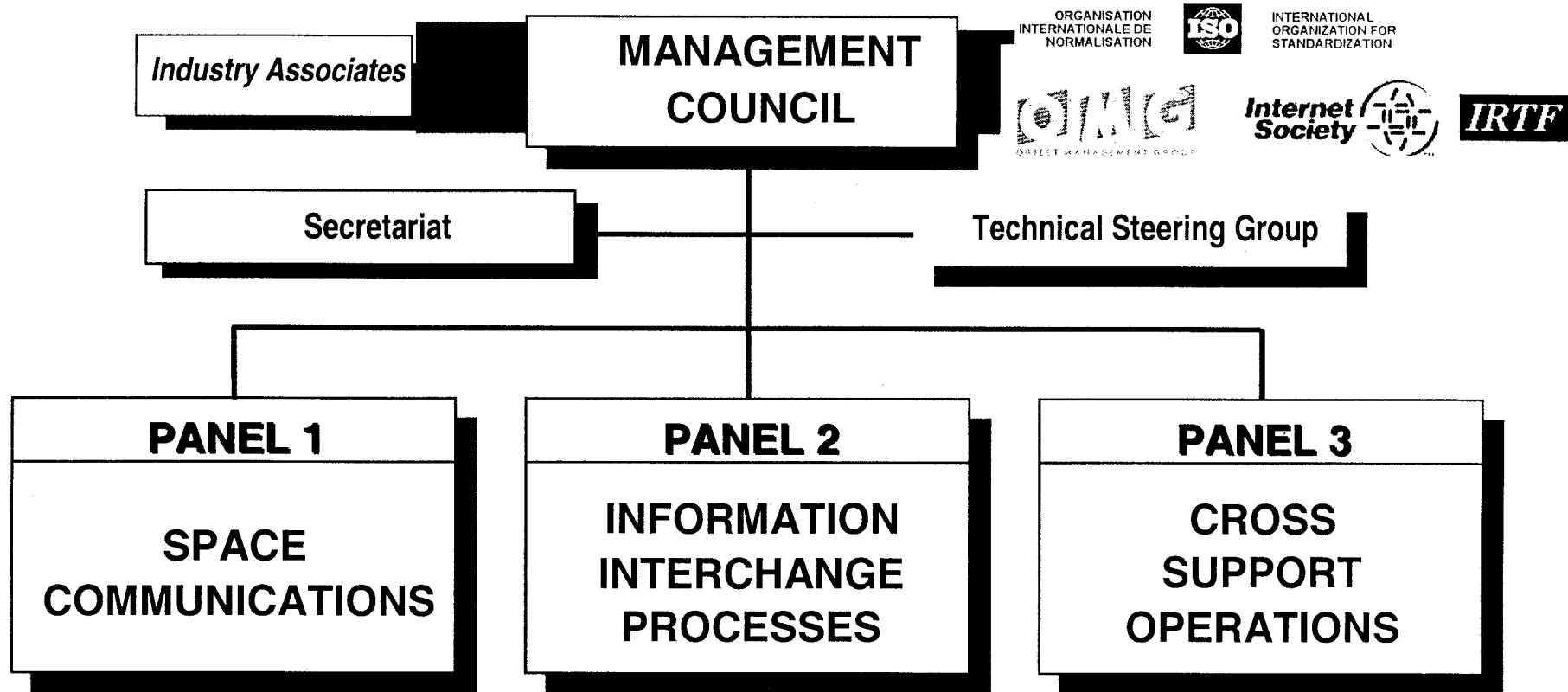Jet Propulsion Laboratory, California Institute of Technology

Model of Space and Range Operations

User Applications

Onboard Networks

Highly Stressed, Resource Constrained Environment

Ground Networks

Telemetry

Radio Links

Telecommand

Radio Links

Current Standards Tracks

Constrained Applications

Constrained Networking

Constrained Links

Space Task Force

OMG

IPNRG

IETF

IRTF

Internet Society

CCSDS

ISO

1. Adopt
2. Adapt
3. Develop

Consultative Committee for Space Data Systems (CCSDS)

Industry Associates

MANAGEMENT COUNCIL

ORGANISATION INTERNATIONALE DE NORMALISATION

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

OMG — OBJECT MANAGEMENT GROUP

Internet Society

IRTF

Secretariat

Technical Steering Group

PANEL 1

SPACE COMMUNICATIONS

PANEL 2

INFORMATION INTERCHANGE PROCESSES

PANEL 3

CROSS SUPPORT OPERATIONS

Member Agencies

ASI/Italy	ESA/Europe
BNSC/UK	INPE/Brazil
CNES/France	NASA/USA
CSA/Canada	NASDA/Japan
DLR/Germany	RSA/Russia

Observer Agencies

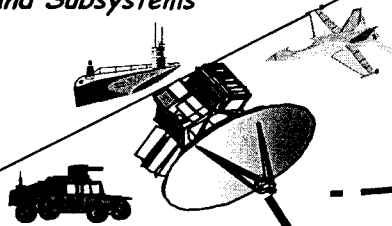|			
ASA/Austria	CTA/Brazil	IKI/Russia	NOAA/USA
CAST/China	DSRI/Denmark	ISAS/Japan	NSPO/Taipei
CRC/Canada	EUMETSAT/Europe	ISRO/India	SSC/Sweden
CRL/Japan	EUTELSAT/Europe	KARI/Korea	TsNIIMash/Russia
CSIR/South Africa	FSST&CA/Belgium	KFKI/Hungary	USGS/USA
CSIRO/Australia	HNSC/Greece	MOC/Israel	

CCSDS Strategic Communications Themes

Develop Interoperable Onboard Interfaces:
"Network Ready" Spacecraft
Devices and Subsystems

Develop Missions as Extensions of the Earth's Internet:
Interface with Near-Earth Constellations
Interface with Commercial Near-Earth Navigation Systems
Interface with Public Media Distribution Systems
Extension of the Internet into Near-Earth Vicinity
Extension of the Internet into Deep Space

Develop Highly Efficient Communications in Resource-Constrained Environments:
Single Aperture/Multi-User Links
Higher Frequency Communications
Efficient Modulation
High Performance Coding
Proximity/In-Situ Communications Links
File Transfer Protocols
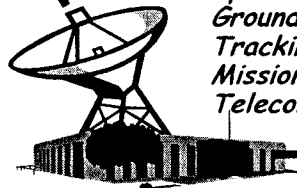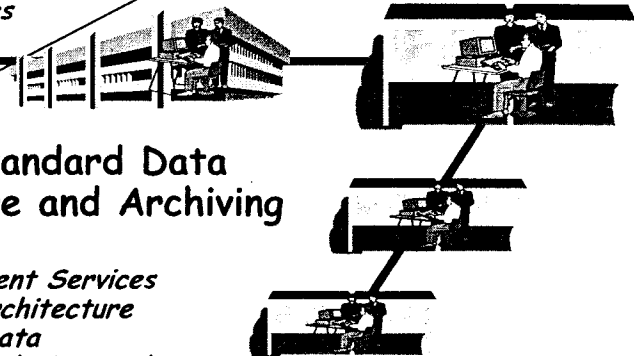Security and Privacy
Advanced Data Compression
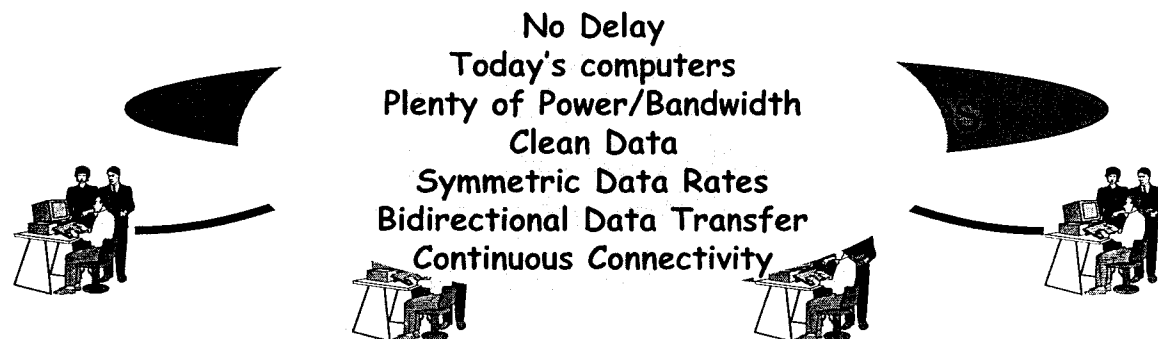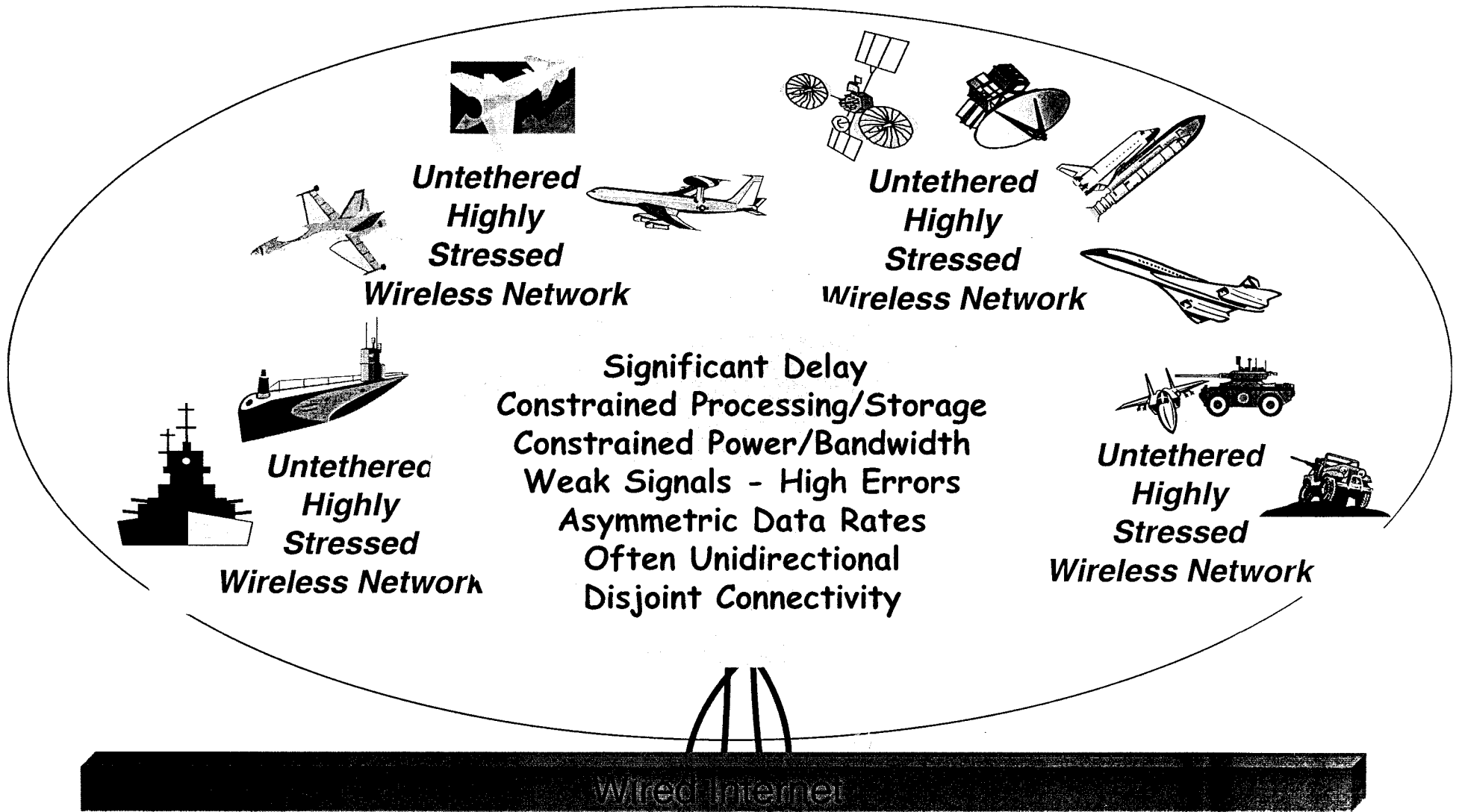
Develop Standard Mission Operations Services:
Space Link Access
Spacecraft Monitor and Control
Ground System Monitor and Control
Tracking and Navigation Services
Mission Planning Services
Telecommunications Services

Develop Standard Data Interchange and Archiving Services:
Data Management Services
Information Architecture
   for Space Data
Space Data Archiving Techniques

Untethered
Highly
Stressed
Wireless Network

Untethered
Highly
Stressed
Wireless Network

Untethered
Highly
Stressed
Wireless Network

Untethered
Highly
Stressed
Wireless Network

Significant Delay
Constrained Processing/Storage
Constrained Power/Bandwidth
Weak Signals - High Errors
Asymmetric Data Rates
Often Unidirectional
Disjoint Connectivity

Wired Internet

No Delay
Today's computers
Plenty of Power/Bandwidth
Clean Data
Symmetric Data Rates
Bidirectional Data Transfer
Continuous Connectivity

App.   App.   App.   App.   App.   App.

Link Terminus

Link Terminus

CCSDS Classic

Application

"Application Over Link"

Application

CCSDS Packet

CCSDS Packet

CCSDS Frames and Coding

Basic CCSDS Space/Ground Communications Protocol Stack

Lossy Data Compression

Lossless Data Compression
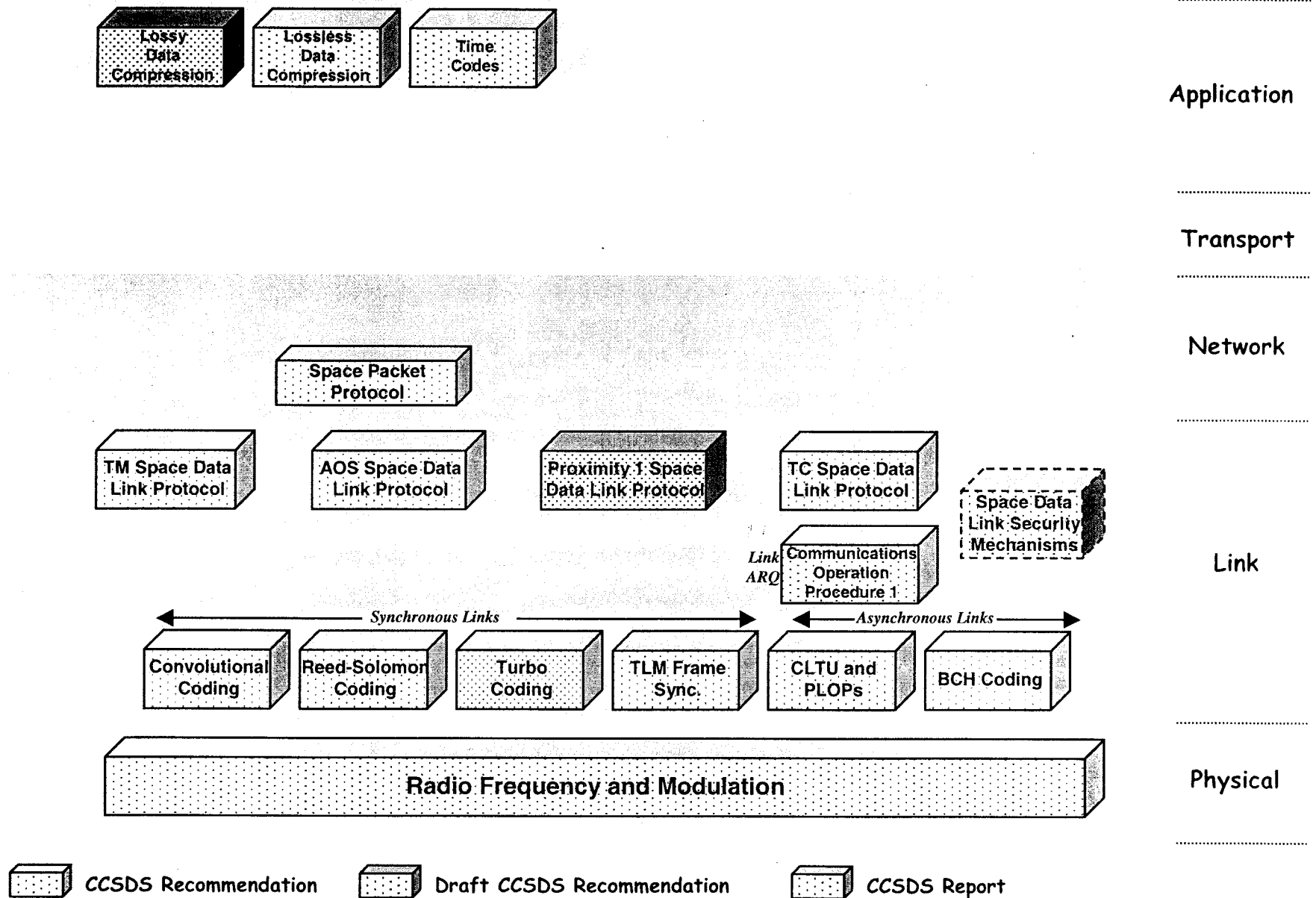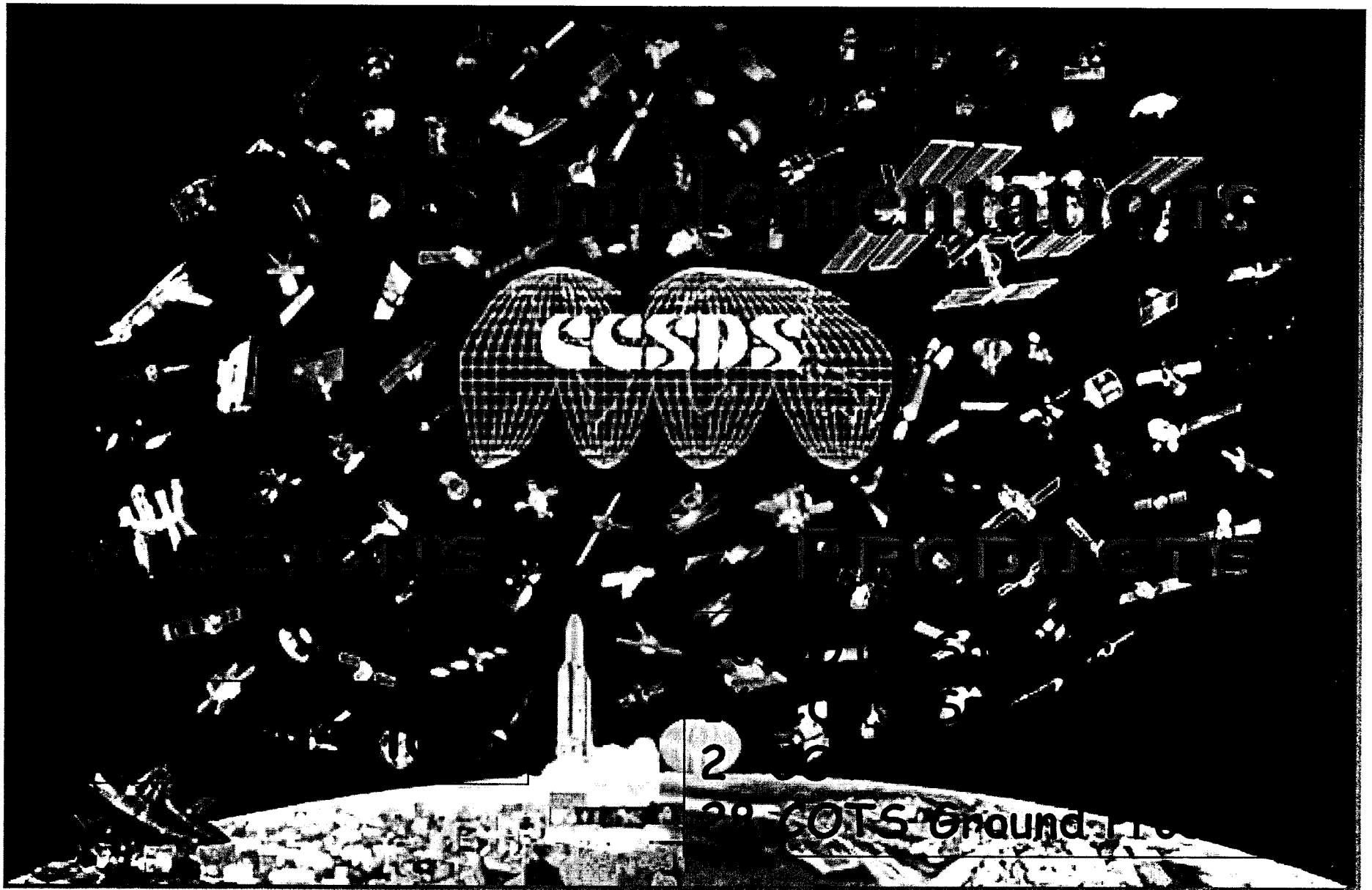
Time Codes

Application

Transport

Network

Space Packet Protocol

TM Space Data Link Protocol

AOS Space Data Link Protocol

Proximity-1 Space Data Link Protocol

TC Space Data Link Protocol

Space Data Link Security Mechanisms

Link ARQ Communications Operation Procedure 1

Link

Synchronous Links → ← *Asynchronous Links* →

Convolutional Coding

Reed-Solomon Coding

Turbo Coding

TLM Frame Sync.

CLTU and PLOPs

BCH Coding

Radio Frequency and Modulation

Physical

CCSDS Recommendation   Draft CCSDS Recommendation   CCSDS Report

CCSDS

http://hope.gsfc.nasa.gov/ccsds/implementations/

Emerging CCSDS ➡ "Application Over Network"

App.   App.   App.   App.   App.   App.

Onboard Network   Link Terminus   Link Terminus   **Ground Network**
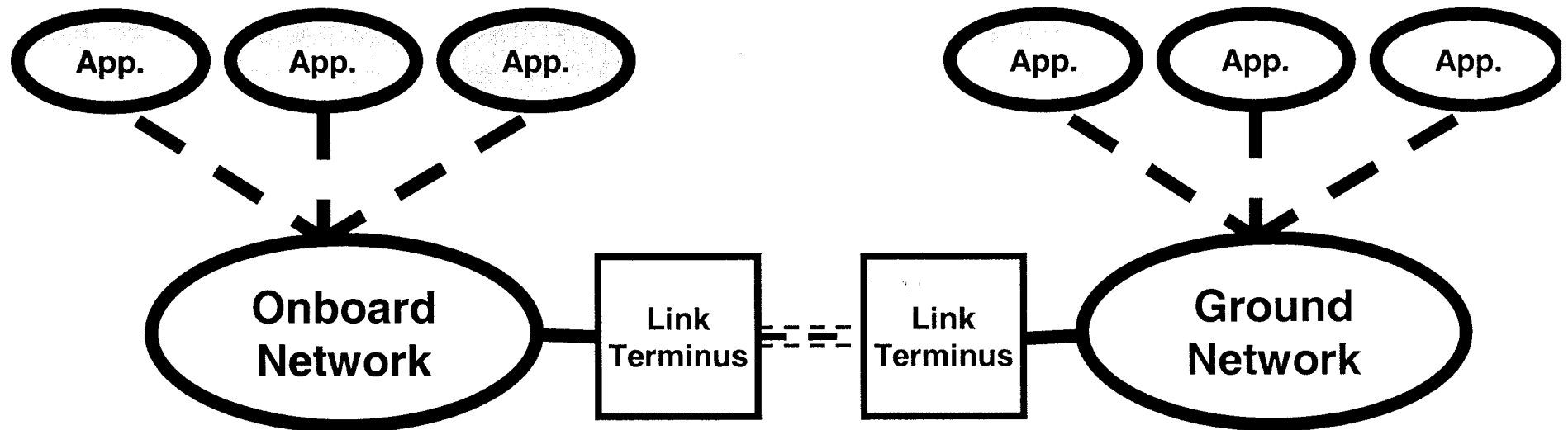
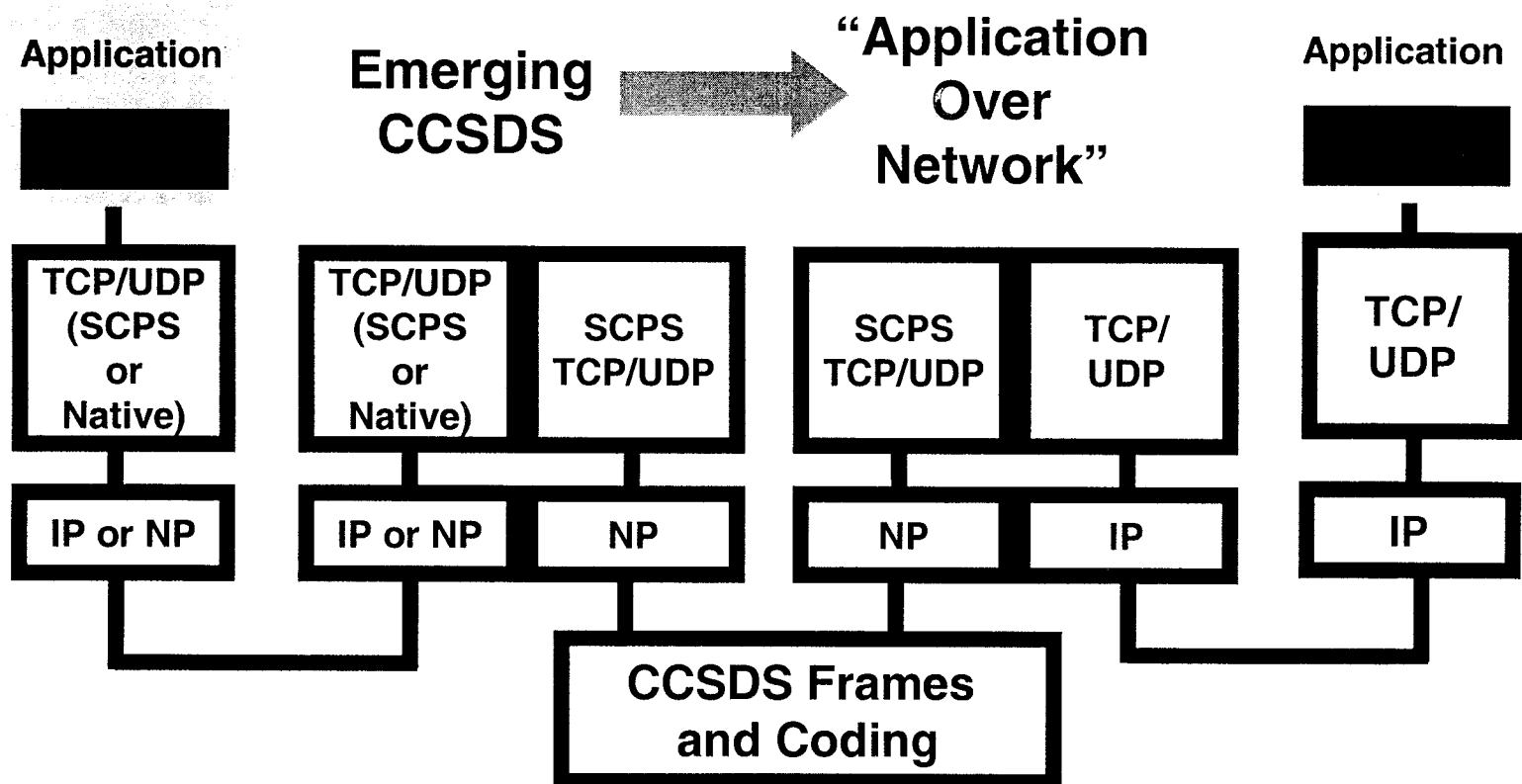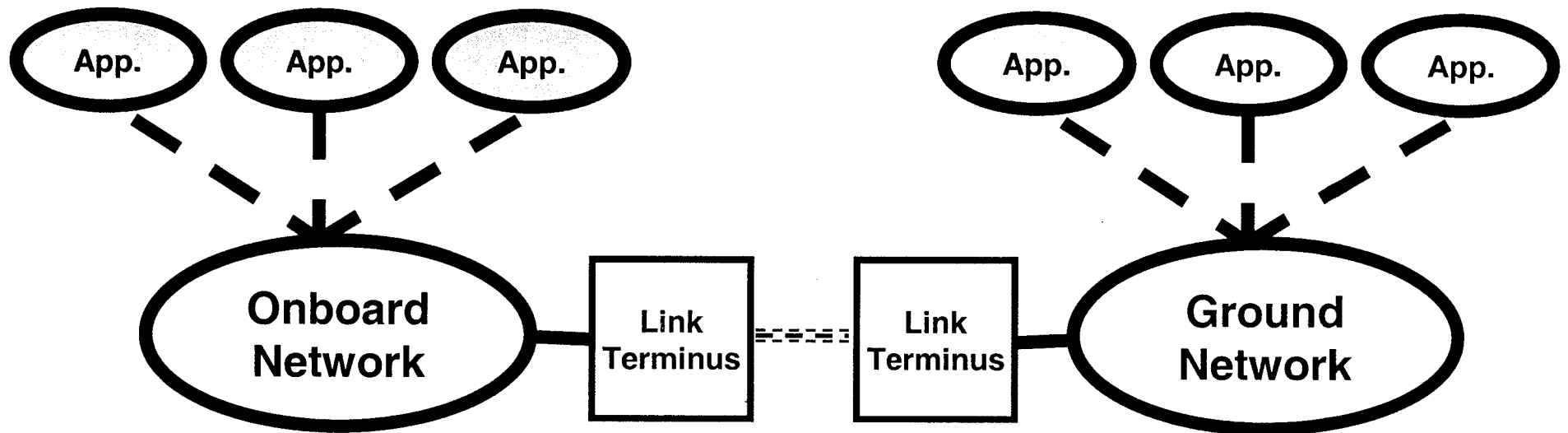# Current CCSDS Space/Ground Communications Protocol Stack

SOIF: *Spacecraft Onboard Interface Standards*

Space App. Standards

Lossy Data Compression

Lossless Data Compression

Time Codes

Store and Forward

Interactive

Onboard Navigation

CCSDS File Delivery Protocol (CFDP)

SCPS-FP Space FTP

Internet FTP

SCPS-TP SpaceTCP/UDP

Internet TCP/UDP

Application

Transport

Onboard Comm Standards

SCPS-SP Space Security Protocol

Internet IPSec

Network

Space Packet Protocol

SCPS-NP Space Network Protocol

Internet Protocol (IPv4, IPv6)

Onboard Bus and LAN Standards

TM Space Data Link Protocol

AOS Space Data Link Protocol

Proximity-1 Space Data Link Protocol

TC Space Data Link Protocol

Space Data Link Security Mechanisms

Link ARQ Communications Operation Procedure 1

Link

Synchronous Links ──────────▶   ◀── *Asynchronous Links* ──▶

Convolutional Coding

Reed-Solomon Coding

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TLM Frame Sync.

CLTU and PLOPs

BCH Coding

Radio Frequency and Modulation

Physical

CCSDS Recommendation   Draft CCSDS Recommendation   CCSDS Report   Internet RFC

What's Hot in CCSDS?

Onboard Navigation

SOIF:
Onboard Bus, LAN ,
Communication and
Application Standards

Proximity-1:
possible next
generation
CCSDS
Link Protocol?

CFDP:
Custodial file protocol
for Store and Forward
operations

SCPS:
Internet-over-CCSDS
for real-time
Telescience

Pink Sheets for
direct multiplexing
of IP/NP into
CCSDS Frames

SLE:
Space Link Extension Services
for accessing and
managing the space link

What Next?

- **Band together to stimulate a "common market" for COTS products by initiating a strong national program**
  - initial focus on developing an open, interoperable stack of bandwidth and power-efficient wireless communications protocols for use by:
    - *DOD Ranges*
    - *DOD Space*
    - *Civil Aeronautics*
    - *Civil Space*
- **Synchronize this national program with the international community by orchestrating its participation in open standards organizations**
- **Seek early opportunities to experiment with interoperability and gain hands-on experience with current and emerging standards**

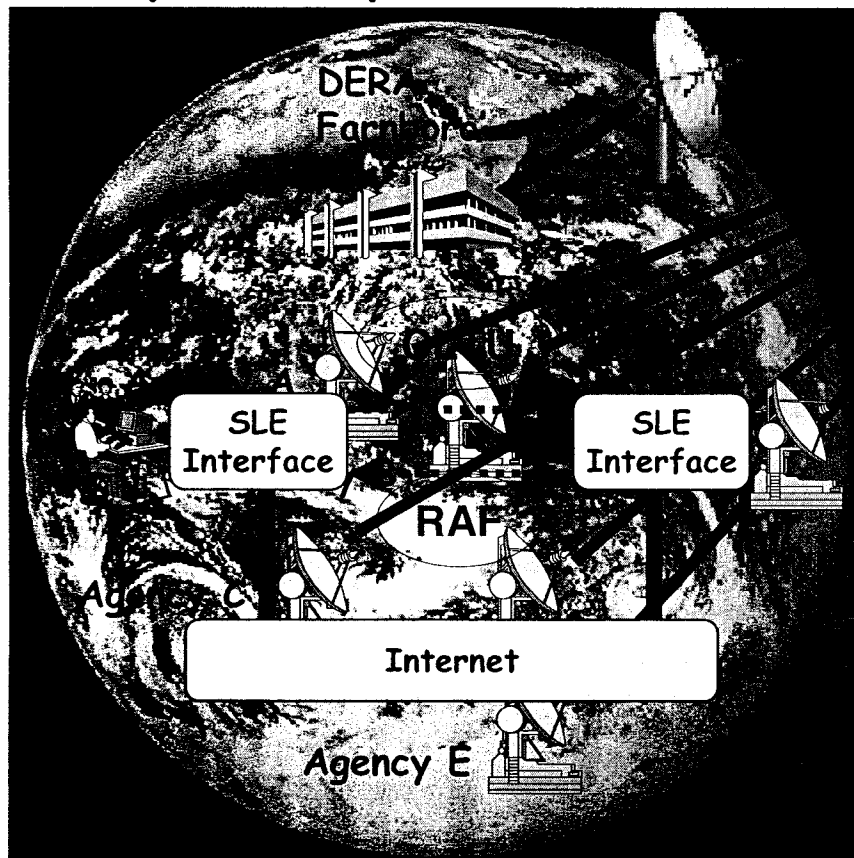# Space Technology Research Vehicle STRV-1D Flight Protocol Tests

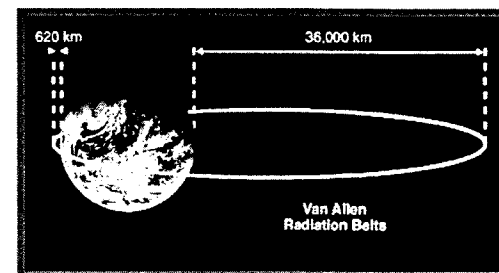*Encrypted CCSDS Security Experiment (ECSE):*
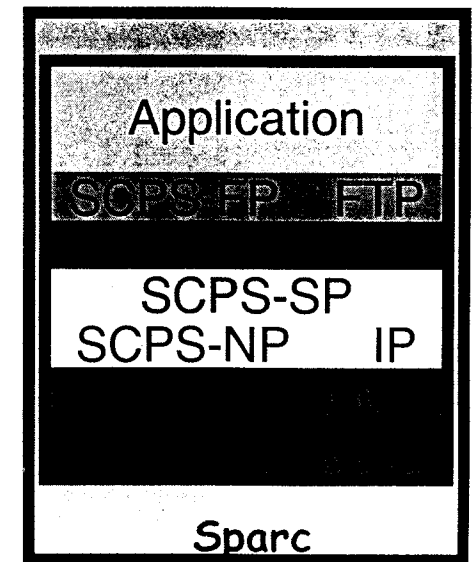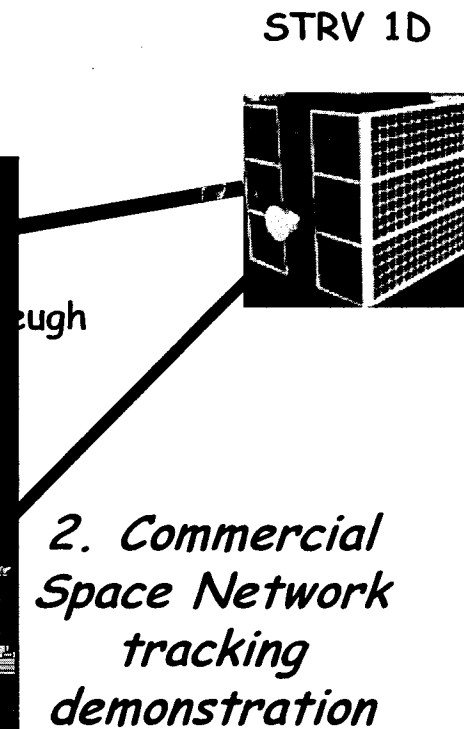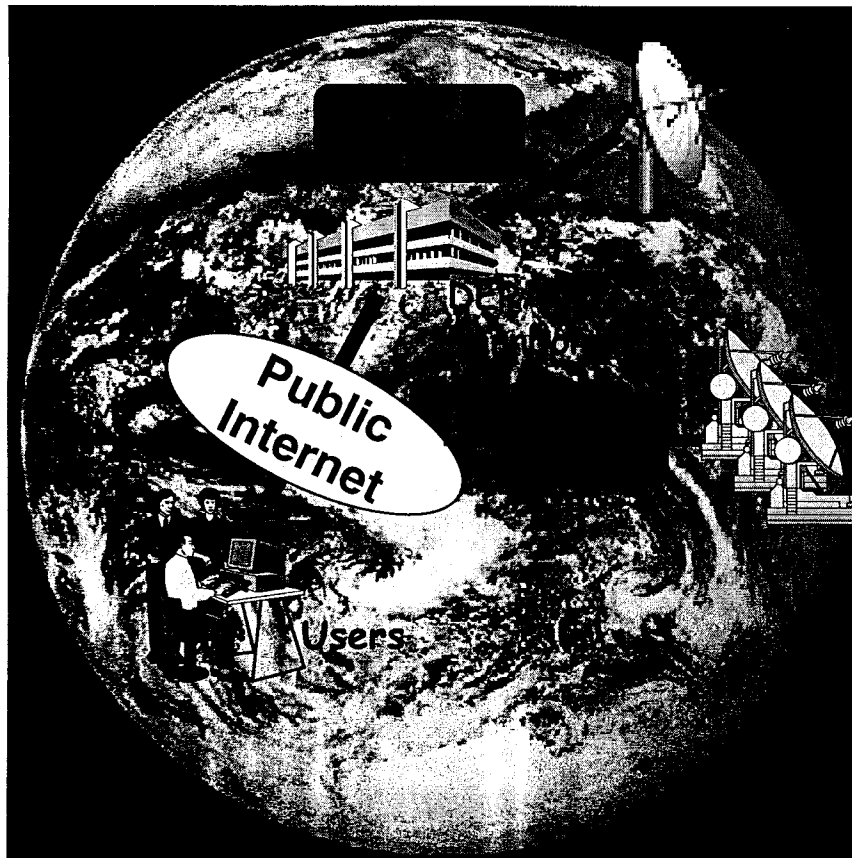*secure space link*

STRV 1D

Application

Sparc

CCSDS Link Interoperability

W.Freugh

DER Facility

SLE Interface

SLE Interface

RAF

Agency C

Internet

Agency E

CSDS Space ink Extension

620 km   36,000 km

Van Allen Radiation Belts

Space Technology
Research Vehicle
STRV-1D :

"Internet-in-Space"
Demonstrations

STRV 1D

Application
SCPS-FP   FTP
SCPS-SP SCPS-NP   IP
Sparc

1. Internet Protocol
Suite demonstration

ugh

Public
Internet

Users

2. Commercial
Space Network
tracking
demonstration

Space Technology Research Vehicle STRV-1D :

CCSDS File Delivery Protocol (CFDP) Flight Test